Claims

What is claimed is:

1. A method of forming a thin film or coating made of nanostructured particles having a particle size less than 100 nm, the method comprising the step of thermally spraying a solution of a liquid coating precursor feedstock onto a substrate to form said film or coating.

2. The method of Claim 1, wherein the thin film or coating has a thickness of about 100 nanometers or larger.

3. The method of Claim 1, wherein the thin film or coating is made of more than one layer by thermally spraying different precursor feedstock solutions.

4. The method of Claim 1, wherein the composition of the precursor feedstock is varied to form a composition gradient coating having nanoparticle size particles of less than 100 nm.

5. The method of Claim 1, wherein the thin film or coating materials are selected from the group consisting of ceramics-ceramics; metal-ceramics; metal-metal; organic-inorganic and mixtures thereof.

6. The method of Claim 1, wherein an external energy source is applied during the coating process or during a post deposition period to modify the coating.

7. The method of Claim 1, wherein the temperature of the thermal spraying is controlled so that the liquid feedstock is not vaporized before it reaches the substrate.

8. The method of Claim 1, wherein the coating precursor feedstock is selected from the group consisting of an aqueous solution of aluminum nitrate, an alcohol-water solution of aluminum tri-secbutoxide, and alcohol-water solution of zirconium n-propoxide, an alcohol-water solution yttrium nitrate and zirconium n-propoxide, and mixtures thereof.

9. The method of Claim 3, wherein the different precursor feedstock solutions are sequentially applied in the same thermal plasma spray apparatus.

10. The method of Claim 1, wherein the coating precursor feedstock further comprises suspended particles.

11. The method of claim 11, wherein the suspended particles are nanostruuctured particles.

12. The method of Claim 11, wherein the coating precursor feedstock further comprises a surfactant to allow the nanostructured particles to be somewhat agglomerated to only a few microns.

13. The method of Claim 1, wherein the droplet size of the solution feedstock is controlled and varied.

14. The method of Claim 13, wherein the droplet size is reduce by placing a fine screen mesh between the spray nozzle and the substrate.

15. The method of Claim 1, wherein the residence time, the in-flight temperature of droplet, and the working distance to the substrate are controlled to control the structure and the microstructure

of the deposited coatings.

16. The method of Claim 1, wherein the spraying is controlled so that fine droplets are allowed to solidify before reaching the substrate by controlling the in-flight temperature whereby the resulting splat will have a smaller dimension compared to that obtained by using a powder feedstock.

17. The method of Claim 1, wherein the spraying is controlled so that the droplets are allowed to reach the substrate in the liquid state whereby solidification of droplets at the substrate will also lead to finer splat microstructure and better chemical mixing when more than a single phase of materials are sprayed.

18. A thin film or coating on a substrate made of nanostructured particles which have a particle size of less than 100 nm .

19. A thin film or coated material made by the method of Claim 1 having a nanostructured material with a particle size of less than 100 nm.

20. A multilayer thin film or coated material made by the method of Claim 3, having a nanostructured material with a particle size of less than 100 nm.

21. The multilayered thin film or coated material of Claim 20, having a nanostructured graded material and fine scale grading, both compositionally and microstructurally.

22. The multilayered thin film or coated material of Claim 21, wherein the layers are integrated by gradually graded interfaces rather than abrupt interfaces so as to permit the compatibility of hybrid multilayered materials.

23. The multilayered coated material of Claim 22, wherein the hybrid multilayered materials are selected from the group consisting of ceramics-ceramics; metal-ceramics; metal-metal; organic-inorganic and mixtures thereof.

24. The multilayered coated material of Claim 21, wherein the grading is microstructural, structural and chemical with continuous interfaces at a fine scale.

25. A graded thin film or coated material made by the method of Claim 4, having a nanostructured graded material and fine scale grading, both compositionally and microstructurally.